with the State for this work. These, of course, cover Government or State lands. In other sections there are favorable opportunities for irrigation of lands already in private ownership. Such enterprises will require an investment of comparatively large amounts of capital. Heretofore such investments have not been profitable because of the lack of railroad transportation. There was no incentive to invest in the irrigation of lands, no matter how productive those lands might be, unless means were provided whereby the crops raised could be transported to market. The present prospects, however, for railroad extension into this territory places these projects in an entirely new light, and the development that is sure to follow the construction of railroads will far exceed our fondest hopes.

In all cases the one feature that determines the feasibility of these projects is that of water supply. The physical difficulties involved in the construction of dams, canals, and other irrigation works can be easily overcome, but the determination of water supply involves the element of time to such an extent that the problems connected therewith are not so readily solved.

The water to be utilized on the land is to be drawn from the streams. In nearly every case the entire yield of the drainage area must be utilized in order to furnish a sufficient amount for the lands that lie favorably for irrigation from them. This requires an extensive development of storage reservoirs. In nearly every case the amount of land that can be reclaimed is dependent solely upon the amount of water that can thus be rendered available for this purpose. The necessity, therefore, of securing reliable water supply data can not be too strongly urged. The determination of this important feature involves careful measurement of all the streams in the territory and a determination of the actual amount of water flowing each day in a year. The relation which stream flow bears to the rain and snow fall makes it necessary to study exhaustively the climatic conditions that obtain here. In this country the inhabitants are so scattering that it is almost impossible to secure local observers of rainfall, temperature, or of river gage heights at the points desired. In the determination of rain and snow fall, observations should be made at the higher altitudes. In these localities no inhabitants are found. The selection of rainfall stations, therefore, has been governed by the facilities for securing observations rather than by physical requirements.

In 1903 the United States Reclamation Service instituted an investigation of the water supply for certain projects that were then under consideration. It was found that the knowledge required to determine the feasibility of these projects was entirely inadequate, and that nothing definite could be done toward construction work until more information on the available water supply could be secured. Funds, however, were not available for a continued study of the streams necessary, and only a few of the more important stations were maintained.

In 1908 a systematic study of the water supply of central Oregon was undertaken by the United States Geological Survey in cooperation with the United States Reclamation Service, the United States Weather Bureau, and the State of Oregon. An engineer was put into the field to install rain and snow fall stations and gages at desired points on the streams of the territory. The determination of stream discharge requires frequent visits to these stations. At every visit measurements of discharge are made by means of a current meter. When these measurements or gagings cover a sufficient range in the stage of the streams, rating tables for each station can be prepared that will indicate the discharge in cubic feet per second for every stage of the river as indicated by the gage. Since gage readings are secured every day by local parties, it is thus possible to determine the discharge every day. The results of these investigations appear in the annual publications of the United States Geological Survey. Those for 1903 will be found in Water Supply Paper No. 100; those for 1904 in Nos. 133, 134, and 135; those for 1905 in Nos. 176, 177, and 178; those for 1906 in Nos. 212, 213, and 214; and those for 1907–8 in Nos. 250, 251, and 252. Of the last 3 papers, only No. 252 has as yet appeared in print.

The records obtained at the rainfall stations are published in the periodic reports of the United States Weather Bureau. Since July, 1909, these will be found in the MONTHLY WEATHER REVIEW and in the separates of the 12 districts into which the United States has been divided for this work.

In addition to these rainfall and stream flow stations, a limited amount of data on the evaporation from water surfaces was secured. Evaporation pans were installed in Harney Lake, Christmas Lake, and in Klamath River. While these data are meager, incomplete, and widely scattered, they nevertheless furnish some very necessary information when investigating the feasibility of storage projects.

The funds available for these investigations of water supply have not been commensurate with the necessity for the data, and on this account it has been necessary to spread the limited funds over a wide expanse of territory. Were it not for the cooperative agreements between the organizations above mentioned, investigations would not have been possible. The United States Geological Survey, through its engineers, secure data in the field, and analyze and publish them. The United States Reclamation Service pays one-half the cost of field examinations for the investigation of stream flow.. The United States Weather Bureau has equipped with meteorological instruments, and furnished and paid observers for precipitation stations, and has compiled, analyzed, and published rainfall and snowfall data. The State of Oregon, through its State Engineer, is cooperating with the United States Geological Survey in securing stream-flow data in the State. There is available each year by legislative appropriation $2,500 for this cooperation. This money is expended under the direction of the United States Geological Survey, a portion thereof being used for the investigations in central Oregon.

In addition to the Government bureaus engaged in this cooperative work, the support of a number of irrigation and power companies in the territory has been enlisted. In this manner gage observations at many of the stations have been secured. At other points rainfall and snowfall data are being furnished voluntarily. No better plan of securing scientific data of this nature can be devised than that of hearty cooperation between all parties interested. In this work the State is probably the chief beneficiary. The Government's interest lies in the fact that the development of these nonproducing areas add homes to our civilization.

IRRIGATION IN THE WILLAMETTE VALLEY.

By JOHN H. LEWIS, State Engineer.

For many years grain growing has been the leading industry of the Willamette Valley, all of which is in private ownership. The average farm is probably 640 acres in extent, the tendency being to increase, rather than decrease, such area, because of the diminished yield to constant cropping. Diversified farming has been urged of late as a remedy, but this is possible only on selected lands which are retentive of moisture, or those which receive moisture through subirrigation. It is not contended that irrigation is necessary for all crops, for deep-rooted plants such as orchards are not affected by the long, dry summer. But for truck garden, alfalfa, clover, small fruits, and vegetables, irrigation in reasonable quantities is absolutely necessary for the highest yield.

Dairying is destined to become the leading industry of the valley, because of the mild, open winters. The most serious obstacle, however, is the long, dry summer, when it is necessary to carry the herd on dry feed, the same as during the winter months in the East. This condition, however, can easily be remedied through the artificial application of moisture. It has

been conclusively proven that 3 full crops of clover, together with fall pasture, can be produced with irrigation, where only one crop, with pasture, is available under present conditions.

Also,4 crops of alfalfa, with pasture, can likewise be produced. It is reported that the milk condensery at Hillsboro was compelled to close down because of the great falling off in the milk supply during the past summer. This is a serious matter and calls for investigation and remedy, otherwise the growth of one of our leading industries will be seriously retarded.

Less than 7 per cent of the total precipitation in the Willamette Valley falls during the summer months. During this same period in an irrigated country the equivalent of the entire annual precipitation is applied to the growing crops. It may be surprising to know that the summer precipitation at Denver, Colo., is 4.4 inches; at Cheyenne, Wyo., 5 inches, and at Santa Fe, N. Mex., 6.2 inches, as compared with 2.6 inches at Eugene. The summer conditions are, therefore, more arid in the Willamette Valley than in these arid States. During the spring seed-germinating period, which is the most deficient period for the irrigator, nature supplies and distributes the moisture. At Milan, Italy, where irrigation has reached a high state of development and has been practised for many years, the summer precipitation is 10.2 inches, as compared with 2.6 inches at Eugene. It is believed that these comparisons conclusively demonstrate a deficiency of summer precipitation.

Drainage in some districts should go hand in hand with irrigation. The quick removal of excessive spring moisture would prevent water-logging of the ground and increase by several weeks the length of the growing season. In other districts the drainage through the porous gravelly subsoil is so perfect that the lands are considered of but little value under present conditions. These lands, when irrigated, will become the most valuable.

In no section of the arid West is the water supply more abundant or more accessible than in this valley. No long feed canals or high diversion dams are required to convey the streams onto the land. If reservoirs must be built in order to prevent conflict with the Oregon City power interests, great latitude in their location is possible, as water can be stored on one tributary and diverted from the regular flow of another.

Aside from the human problem, the determination of the physical data to properly outline a large project in this valley is of the greatest importance. Topographic maps, showing the relative elevations of the valley lands, are necessary in the making of even a preliminary plan, also stream discharge measurements extending over several years.

It is necessary to gather such data at public expense. A small appropriation for such work was made by the legislature in 1905, and already 400 square miles in the vicinity of Eugene have been surveyed and gaging stations established on some of the most important streams. To cover the entire valley, at this rate, will require about 20 years. Our neighboring States are more liberal in promoting their own welfare through the gathering of such data, and the United States, through its Geological Survey, will contribute dollar for dollar with each State in such work. This offer was made at the last 2 sessions of our legislature without avail. California, for the past 6 years, has appropriated annually $40,000, and the survey of the Sacramento Valley is about complete. A gigantic irrigation and drainage project has been outlined and some of the smaller units already are under construction. The State of Washington has recently advanced $20,000 for such preliminary surveys.

The great commercial development which would follow the placing of 10 to 20 families upon each square mile of valley lands, where but one or two now live, should justify the commercial interests of Portland and all valley towns in contributing the preliminary expense by private subscription. If a comprehensive plan for a large reclamation project is presented to the next legislature and its feasibility assured, the necessary money for surveys will doubtless be appropriated.

THE IDAGON IRRIGATION PROJECT.

By EDWARD L. WELLS, Section Director, Boise, Idaho.

The water supply for this project is to be obtained from Succor, Jordan, Cow, Jump, and Sage creeks. The combined available watershed of these various streams amounts to somewhat more than 300,000 acres, lying in Owyhee County, Idaho, and Malheur County, Oregon, ranging in altitude from 2,700 to 8,000 feet above sea level. The precipitation data available for this region are very meager. From such data as are available, engineers have estimated the precipitation as ranging from 12 to 40 inches annually. The watershed includes a considerable portion of the Owyhee Mountains, where the winter snowfall is heavy (fig. 2). This range of mountains is almost wholly devoid of timber, and from this cause, as well as by reason of its isolation from other ranges, is subject to high winds, hence the snow is piled into huge drifts on the leeward side of the ridges, remaining in these drifts till late in summer, and sometimes throughout the year. A large part of the precipitation occurs outside the irrigating season, rendering storage necessary. The water supply has its legal basis on filings as follows:

Succor Creek	500 second-feet.
Jordan Creek	200 second-feet.
Cow Creek	100 second-feet.
Jump Creek	60 second-feet.
Sage Creek	20 second-feet.

The work already done consists of a diverting dam on Succor Creek (G, fig. 1) (fig. 3), at an elevation of 2,400 feet, from which

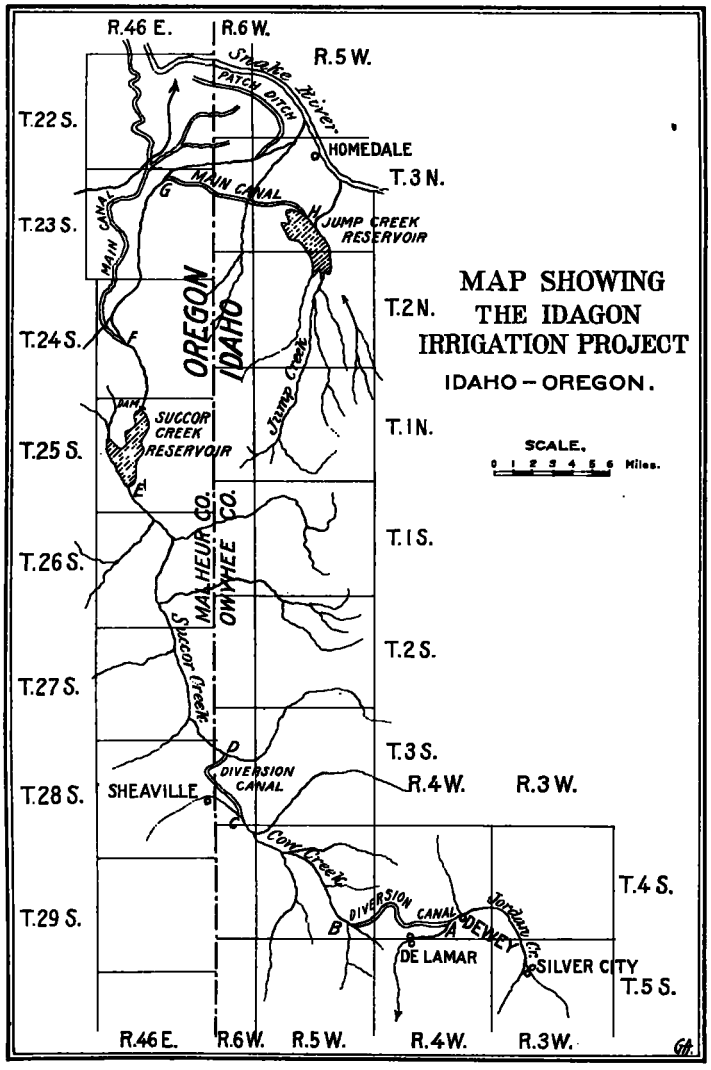

FIG. 1.